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MEASUREMENT OF PRODUCTIVITY AT THE FIRM LEVEL*

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I. INTRODUCTION

1. In Japan, there exist several types of measurements of labour productivity, both value and physical measurements, at national, industry and firm levels. The most important measurements are as follows:

(a) Labour productivity at national level, based on the national accounts statistics;

(b) Labour productivity indices, covering manufacturing, mining and public utilities, compiled by the Japan Productivity Center;

(c) Labour productivity statistical survey, covering productivity at firm level in the manufacturing industry, conducted by the Ministry of Labor.

2. Among these measurements, the third one, the labour productivity survey, may be useful as a guideline for developing firm level productivity measurements. For industries other than manufacturing, although some productivity statistics are compiled from the secondary data, firm level measurements by direct survey method are not available.

II. BACKGROUND

3. It was after the World War II, that the importance of labour productivity was widely recognized in Japan. For the recovery of the war-devastated economy and for the expansion of export trade, increase of labour productivity was one of the most important factors. Therefore, correct information on the labour productivity concerning the Japanese economy became absolutely necessary.

4. As for the productivity statistics, shortly after the war Japan began compiling over-all labour productivity indices for manufacturing, which were derived by dividing the production indices by the employment indices.

5. After some preliminary surveys, the "Labor Productivity Statistical Survey", covering four industries, namely cotton spinning, ammonium sulphate, cement, and iron and steel, was conducted for the first time in 1952.

6. The scope of the survey was revised several times and the under-mentioned additions and deletions were made:

1954 Rayon, paper, pulp, motor vehicles, and steel rolling were added.

1955 Soda, carbide, tires and inner tubes, wool spinning, and electric motors were added.

1962 Cotton and spun rayon fabrics, lathes, steel and iron castings, bearings, and watches were added.

1967 Plywood, and electric wire and cable were added, but carbide was excluded.

1980 Watches were excluded.

/III.

III. CHARACTERISTICS OF THE SURVEY

A. OUTPUT

7. Output is measured in physical terms (e.g. tons of cotton yarn, square meters of fabrics, tons of pig iron, number of electric motors, number of passenger cars).

8. If the products are homogeneous or considered to be fairly homogeneous, the output data can be aggregated without much difficulty. Examples are: pig iron produced by blast furnace, cement. However, when the products are heterogenous, the measurement of output is not so simple.

9. In such a case, two methods are adopted to measure output of heterogeneous products. One is the use of conversion ratios. In some industries, one of the products is selected as a standard and other products are converted into standard units by using coversion ratios. Examples are: cotton yarn, woollen yarn, tires and inner tubes. In the case of cotton yarn, yarn count 20 (written as 20^s) is used as a standard, and the output of other counts of yarn is converted into the output of this count of yarn (20^s).

10. Another method is that output is measured for each product, or for a group of products which can be considered as fairly homogeneous. Examples are: paper, steel rolling, motor vehicles. In the case of paper, the output is measured for each of the following products.

Paper:	Paper board:
(1) newsprint paper	(1) liner
(2) printing paper	(2) corrugating medium
(3) kraft paper	(3) board
(4) tissue paper	(4) miscellaneous
(5) sanitary paper	
(6) miscellaneous	

B. INPUT

11. Input data are measured by hours worked of production workers for each production process. Managerial and clerical workers are not covered. A few examples of production process are given below.

Cotton spinning industry:

Direct

(1) Bale opening, mixing
(2) Carding
(3) Combing
(4) Drawing
(5) Roving
(6) Spinning

/Indirect

Indirect

Repairs, electricity, boiler, air conditioning.

Gray iron castings:

Direct

(1) Sand preparation
(2) Molding
(3) Melting
(4) Cores
(5) Heat treatment
(6) Finishing

Indirect

(1) Conveyance
(2) Testing and inspection
(3) Repairs
(4) Power station

C. LABOUR PRODUCTIVITY

12. Labour productivity is measured as working hours required for production of unit product. Therefore, labour productivity (unit labour requirements) may be expressed by:

$$\frac{m_1}{q} \ , \ \frac{m_2}{q} \ , \ \ldots\ldots\ldots\ldots \frac{m_n}{q}$$

where m_1 , m_2, ... m_n are hours worked at the production process 1, 2, ..., n.

q is the output of the product

This expression is the reciprocal of the commonly used expression of labour productivity. The main advantage of this expression, hours worked per unit of product, is that they can be directly added or subtracted. It is possible to compute the number of hours of work necessary to perform the different phases of a production process, and, therefore, to compare from plant to plant the labour productivity, even when some parts of the production process of each plant are different.

13. For example, if comparisons are required between two cotton textile plants, where in one plant the cotton is spun and then woven, while in the other only the weaving stage is performed, it will be possible for the first plant to show separately, in the total unit labour requirements, those needed to spin the cotton data collected for the second plant.

IV. SURVEY METHODOLOGY

14. The survey is carried out in February of each year (1) covering the period January to December of the previous year for the following industries: cotton spinning, wool spinning, cotton and spun rayon fabrics, steel and iron castings, lathes, and (2) covering the period October to November in the case of other industries.

/15.

15. The survey is carried out by the mail system. A personal interview survey by our staff members is also carried out to obtain more detailed information, especially on the factors affecting labour productivity.

16. Two types of schedules are used for obtaining data for each industry. The first one is the main schedule, in which data on output and input are collected, and the other a supplementary schedule in which data on factors influencing labour productivity are collected.

17. The survey items of the above mentioned schedules are as follows:

(a) Main schedule

(i) Name of the establishment

(ii) Location of the establishment

(iii) Output of main products

(iv) Hours worked for the production of these main products by production process

(b) Supplementary schedule

(i) Main equipments, machinery and its rate of operation

(ii) Number of workers by production process

(iii) Change in the number of workers from previous years and reasons for the change

(iv) Measures taken by the establishment to increase labour productivity (description according to the following items)

(1) Introduction of new equipments

(2) Automatization of equipments

(3) Concentration of production on high capacity equipments

(4) Shortening of production process

(5) Improvement of equality control

(6) Decrease in the number of parts

(7) Reallocation of workers

(8) Employment of temporary or part-time workers

(9) Introduction or improvement of shift system

(10) Changes in working hours

(11) Small group activity (e.g. Quality control circle, Zero defect movement)

(12) Improvement in work motion

(13) Others

V. COVERAGE

Industries and products

Industries	Products
Cotton spinning	cotton yarn
Wool spinning	worsted yarn, woolen yarn
Cotton and spun rayon fabrics	broad woven fabrics
Plywood	plywood
Pulp	(sulphite pulp, kraft pulp, (semi chemical pulp, chemiground (pulp, ground pulp
Paper	machine made paper, paper board
Ammonium fertilizer	ammonium sulphate, urea
Soda	caustic soda
Rayon	(rayon filament, rayon staple (filament
Tires and inner tubes	(tires and inner tubes for motor (vehicles
Iron and steel	(pig iron produced by blast furnace (steel ingot (by converter (by electric furnace
Steel rolling	hot rolled steel, cold rolled steel
Steel and iron casting	(steel casting, gray iron casting (malleable iron casting
Electric wire and cable	bare wire
Lathes	lathes
Bearings	ball bearings, roller bearings
Electric motors	standard induction motors (capacity of 11 kW and under)
Motor vehicles	motor vehicles (cylinder displacement over 550^{cc})

/Watches

Watches (excluded in 1980)	wrist watch movements (mechanical type)

18. In the case of 12 industries, establishments, which produce the above-mentioned products, are surveyed by complete enumeration.

19. In the case of the other 8 industries (cotton and spun rayon fabrics, plywood, pulp, paper, iron and steel, steel rolling, steel and iron casting, electric wire and cable), random sampling method or cut-off sampling method is applied to select survey establishments.

20. The number of establishments surveyed is roughly 2,000.

VI. CALCULATION PROCEDURES

21. Industries which have a single product:

In this case, the labour productivity or the unit labour requirements is computed as:

$$l = \frac{m}{q}$$

where

l : labour productivity (unit labour requirements)

m : man-hours worked for the production of q

q : output of the product

The index number of labour productivity is simply a ratio of two periods of time.

This ratio can be expressed as follows:

$$li / lo$$

where lo : represents labour productivity at the base period.

li : labour productivity at the period i.

Industries which have two or more products:

For an industry which has two or more products, the labour productivity for each of the products is calculated as:

$$l^{(i)} = \frac{m^{(i)}}{q^{(i)}}$$

where

$l^{(i)}$: labour productivity for product i

/$m^{(i)}$

$m^{(i)}$: man-hours worked for the production of $q^{(i)}$

$q^{(i)}$: output of the product i

The labour productivity index for each product can be calculated by the same method mentioned above.

The index for product i is:

$li^{(i)} / lo^{(i)}$ or simply li / lo

The labour productivity index for such industry can be expressed as follows:

$$\Sigma \left(\frac{qo\ lo}{\Sigma qo\ lo} \right) \frac{li}{lo} \qquad \ldots\ldots\ldots\ldots \quad (A)$$

where

lo : labour productivity for one of the products at the period 0

li : labour productivity for the same product at the period i

qo : quantity of the product produced at the period o

This formula (A) is the weighted average of labour productivity index for each product. And the weight is the base period labour input weight.

This formula (A) can be converted as:

$$A = \frac{\Sigma qo\ lo \times \frac{li}{lo}}{\Sigma qo\ lo} = \frac{\Sigma qo\ li}{\Sigma qo\ lo} \qquad \ldots\ldots\ldots \quad (B)$$

Therefore the meaning of this formula (B) can be explained as the ratio of the total labour that would have been spent to produce base period complex of products, with the current unit labour requirements, to the total labour actually spent in the base period.

The general index for the total of all surveyed industries can be calculated by a method similar to the formula (A).

VII. RECENT RESULTS

22. Table 1 shows that in 1979, labour productivity in the covered industries increased by 8.4 per cent, a little larger than 8.2 per cent of the previous year.

23. In 1979, labour productivity increased in all of the survey industries, and especially in the industries of soda, cotton spinning, ammonium fertilizer, tires and inner tubes, electric motors, watches, steel and iron castings, pulp, in which the rates of increase were larger than 10 per cent. From 1973 through 1979, labour productivity in the covered industries increased at an average annual rate of 4.5 per cent. The average annual rate of productivity change for 1973-1975 was minus 1.8 per cent, reflecting the oil crises in 1973.

/Table 1

Table 1. Annual rate of productivity change by industry

(%)

Industry	1978	1979	Average rate		
			1973 1979	1973 1975	1975 1979
Total	8.2	8.4	4.5	- 1.8	7.5
Cotton spinning	10.4	19.5	7.1	- 1.8	11.2
Wool spinning	3.0	6.5	5.3	2.1	6.8
Cotton and spun rayon fabrics	9.1	3.0	5.5	1.2	7.6
Plywood	13.6	9.6	6.4	4,1	10.6
Pulp	2.8	10.4	3.3	- 5.8	7.5
Paper	6.3	7.0	4.5	- 2.9	8.1
Ammonium fertilizer	9.1	15.1	7.4	0.5	10.7
Soda	3.8	27.8	5.6	- 4.9	10.5
Rayon	9.3	4.6	7.4	1.0	10.5
Tires and inner tubes	10.1	12.6	6.6	0.5	9.5
Cement	6.8	5.3	7.6	- 1.0	11.6
Iron and steel	5.9	9.1	1.4	- 6.0	4.9
Steel rolling	6.7	5.3	0.9	- 6.3	4.3
Steel and iron castings	7.3	10.5	5.6	- 0.8	8.7
Electric wire and cable	16.2	3.0	6.4	- 3.9	11.2
Lathes	4.3	6.3	2.6	- 23.4	13.5
Bearings	13.0	7.2	6.8	- 5.1	12.3
Electric motors	7.0	11.4	6.4	0.1	9.4
Motor vehicles	9.5	6.4	6.3	5.0	10.2
Watches	13.0	11.1	9.3	2.5	12.5

Some of the recent results by production process are shown below.

Table 2. Hours worked per ton of cotton (converted into 20^s) by production process

(unit: hours)

Production process	1978	1979
Total	72.61	58.46
Direct	69.79	56.06
Bale opening, Mixing	4.95	4.05
Carding	6.26	5.04
Combing	3.20	2.63
Drawing	5.26	4.26
Roving	9.72	7.30
Spinning	40.40	32.78
Indirect	2.82	2.40

Table 3. Hours worked per ton of castings (gray iron) by production process

(unit: hours)

Production process	1978	1979
Total	23.20	20.68
Direct	19.34	17.12
Sand preparation	0.89	0.75
Molding	7.74	6.94
Melting	2.47	2.16
Cores	3.12	2.62
Heat treatment	0.30	0.30
Finishing	4.82	4.36
Indirect	3.86	3.56
Conveyance	1.09	1.02
Testing and inspection	1.19	1.02
Repairs	1.17	1.13
Power station	0.41	0.38

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